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NUCLEAR SAFETY TECHNICAL REPORT

SAFETY ANALYSIS FOR THE SOLAR PONDS PLUME PROJECT

RMRS Nuclear Safety
Rocky Flats Environmental Technology Site

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Author: Alan R. Hohl	**Revision No.** 0
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Approval: Don Swanson 3/1/99 Don R. Swanson, Manager, Nuclear Safety Process Waste Operations/ER/SS	**Copy No.**

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Author:

Alan R. Hohl 2-24-99

Alan R. Hohl, RMRS Nuclear Safety,
Safety Analyst, ESSCO

Concurrence:

Annette L. Primrose 3-1-99

Annette. L. Primrose, RMRS Project Manager

Reviewer:

John S. Kirar 2/24/99

John S. Kirar, RMRS Nuclear Safety,
Safety Analyst, ESSCO

Concurrence:

SKC 3/17/99

Steve K. Crowe, K-H Division Manager,
Engineering and Integration

2

SUMMARY

This Nuclear Safety Technical Report (NSTR) has been prepared to assess the radiological and chemical hazards associated with the Solar Ponds Plume Project. Review of the Solar Ponds Plume Project activities was based on the *Draft Solar Ponds Plume Decision Document* (Ref. 1). Contaminants of concern data for the project were provided in Ref. 1 as well as in the *OU4 Solar Evaporation Ponds Interim Measure/Interim Remedial Action Environmental Assessment Decision Document* (Ref. 2).

The Solar Ponds Plume Plume Project is located north of the Solar Evaporation Ponds (SEPs) on the northern side of the North Access Road and southeast of the Modular Storage Tanks (MSTs). Leakage from the SEPs has contaminated the shallow groundwater in the area. The Solar Ponds Plume has migrated down the hillside to the north of the SEPs and into North Walnut Creek. The groundwater plume and subsurface soils/bedrock contain metals, volatile organic compounds, and radionuclide contaminants.

Project activities will consist of constructing a subsurface groundwater collection system coupled with a passive reactive media treatment system to treat contaminated groundwater to levels specified in the Rocky Flats Cleanup Agreement (RFCA). The present Interceptor Trench System (ITS) will be left in place to enhance the recovery of the Solar Ponds Plume groundwater. The ITS will be cut during installation of the reactive barrier and the resulting water will be diverted from the ITS to Pond A-1. The diversion, anticipated to last less than six months, will cease upon completion of the installation, at which time the new system will begin treatment.

The project will be conducted in accordance with the RFCA, Department of Energy (DOE) Orders, and Rocky Flats Environmental Technology Site (RFETS) polices and procedures.

Based on the guidance in DOE-STD-5502-94 and the information provided by the project in References 1 and 2, the Solar Ponds Plume Project is classified as *radiological*. The project's *radiological* classification is due to the sum of the ratios of radionuclide contaminants exceeding 1.00, and not due to individual radionuclide contaminants exceeding an RQ. An acute release of a sum of the ratios RQ quantity of radionuclides that could adversely affect the collocated worker or the public is considered improbable due to the nature of the Solar Pond Plume remediation activities.

A *radiological* classification requires compliance with applicable OSHA Standards, preparation of a subcontractor-developed site-specific Health and Safety Plan (HASP), and preparation of an auditable safety analysis (ASA). This document serves as the project's ASA.

Based on the *radiological* classification, the associated hazards do not present any adverse impacts to the public or the environment. Worker safety will be assured through implementation of the site-specific HASP and compliance with *Hazardous Waste Operations and Emergency Response*, 29 CFR 1926.65 (Ref. 3).

SAFETY ANALYSIS
FOR THE
SOLAR PONDS PLUME PROJECT

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1. INTRODUCTION

The purpose of this Nuclear Safety Technical Report (NSTR) is to assess the radiological and chemical hazards associated with the Solar Ponds Plume Project, a project designed to collect and treat contaminated groundwater from the distal end of the Solar Ponds Plume. This NSTR presents a work-site classification with the purpose of determining the type, grading, and complexity of the hazard identification, evaluation, and control documentation (safety analysis) presented later in the document.

1.1 Overview

The Solar Ponds Plume (see Figure 1-1) remediation project consists of the installation of a reactive barrier north of the Solar Ponds on the northern side of the North Access Road to intercept the plume prior to reaching North Walnut Creek. The system will consist of a barrier used to funnel plume groundwater to the reactive media treatment cells. The present Interceptor Trench System (ITS) will be left in place and used to enhance the recovery of the Solar Ponds Plume groundwater. The ITS will be cut during installation of the reactive barrier and the resulting water will be diverted from the ITS to Pond A-1. The diversion, anticipated to last less than six months, will cease upon completion of the installation, at which time the new system will begin treatment.

A collection trench approximately 850 feet long, two to three feet wide, and approximately 20-30 feet deep, will be constructed. The trench will extend approximately ten feet into the weathered bedrock to capture both bedrock and groundwater alluvial flow. An impermeable barrier will be placed on the downgradient side such that the flow is effectively diverted to the treatment cells. The collection trench will be filled with a highly permeable media such as gravel to enhance flow to the perforated PVC pipe and subsequently to the treatment cells. A geotextile will be placed at the top of this media to prevent backfilled soils from settling into the reactive barrier.

The Solar Ponds Plume collection trench will intercept the ITS allowing groundwater collected by the ITS upgradient from the reactive barrier to flow into the new collection trench. The ITS lines downgradient of the reactive barrier will be sealed off at the upgradient end with impermeable material and will permit the ITS to be used to enhance recovery upgradient but not to short circuit the treatment cells at the Solar Ponds Plume collection trench. As part of this remedial action, the trench will be paved or grouted to prevent run-off from flowing into the ITS and the reactive barrier.

The reactive barrier will have treatment cells filled with a mixture of organic media to act as a carbon source for the iron to induce denitrification and zero-valence iron to remove the uranium and nitrates by chemical reduction. The organic media may be peat, sawdust, or other types of organic matter. Multiple treatment cells will be used to better distribute the flow and to divert water away from areas with a high potential for slumping.

3. SITE CHARACTERIZATION

The site characterization data presented in this NSTR is from the Draft Solar Ponds Plume Decision Document (Ref. 1). Surficial and subsurface soil contaminant sampling data specific to the Solar Ponds Plume Project area was extracted from Ref. 2, Section 4, Figures II.4.4-1 through II.4.4-27, and Figures II.4.5-1 through II.4.5-20.

The SEPs, located in the northeastern portion of the Protected Area, were waste-processing units at Rocky Flats from 1953 to 1986. The SEPs were operated primarily to store and evaporate radioactive process wastes and neutralized acidic process wastes containing high levels of nitrate and aluminum hydroxide. Leakage from the SEPs has contaminated the shallow groundwater in the area. The Solar Ponds Plume has migrated down the hillside to the north of the SEPs and into North Walnut Creek.

Previous investigations/studies indicate that the primary contaminants in the Solar Ponds Plume are uranium and nitrate, although other metals such as cadmium and selenium have been detected above background groundwater concentrations. The nitrate plume extends from the vicinity of the SEPs, for approximately 1,400 feet in a northeastward direction to North Walnut Creek, and approximately 1,400 feet to the southeast and east toward South Walnut Creek (Figure 1-1). Available data indicate that the uranium plume is limited to the plateau where the SEPs are located, although it may extend into the ITS. The portion of the Solar Ponds Plume containing the highest nitrate concentrations extends from the northern portion of the SEPs in a northeasterly direction to North Walnut Creek.

Low concentrations of volatile organic compounds (VOCs) (i.e., acetone and toluene) have been identified in the Solar Ponds Plume groundwater; however, in general the concentrations of VOCs in the plume on the northern side of the SEPs do not exceed RFCA Tier II concentrations or are non-detects. Some metals, including selenium, exceed the RFCA groundwater action levels.

Recent investigations and evaluations focused on gathering the information necessary to determine a long-term cost-effective remedial alternative for the Solar Ponds Plume Project. Field investigations were conducted to fill data gaps regarding the nature and extent of the Solar Ponds Plume.

A GeoProbe ™ was used to install four wells in the plume area to determine the nature and extent of the Solar Ponds Plume (nitrate/nitrite and uranium) in the unconsolidated deposits, weathered bedrock, and competent bedrock during the low-flow (late fall/early winter) and high-flow seasons (spring). The amount and distribution of naturally occurring uranium present in the Solar Ponds Plume groundwater was also assessed.

Fifteen boreholes were placed throughout different parts of the Solar Ponds Plume area and were used to collect surficial and subsurface soil contaminant characterization data found in Ref. 2, Section 4, Figures II.4.4-1 through II.4.4-27, and Figures II.4.5-1 through II.4.5-20. Solar Ponds Plume radionuclide and chemical contaminant descriptions are provided in the following sections.

3.1 Radionuclides

References 6, 7, 8, and 9 were used to screen the radionuclides of concern as discussed in section 5.1.2. Radionuclide concentrations in Solar Ponds Plume groundwater are at or below background concentrations, and below or near RFCA levels.

Results from borehole samples collected on the south side of the Solar Ponds Plume source areas were well below the RFCA levels for radionuclides in subsurface soil. Americium-241, plutonium-239/240, uranium-233/234, uranium-235, and uranium-238 were found to be present. The maximum detected concentrations of radionuclides in the subsurface soil/bedrock and groundwater are provided in Table 3-1 below. Ref. 2, Section 4, Figures II.4.4-1 through II.4.4-27, and Figures II.4.5-1 through II.4.5-20, provides surficial and subsurface soil contaminant sampling data specific to the Solar Ponds Plume Project area.

3.2 Chemical Compounds and Metals

References 6, 7, 8, and 9 were used to screen the chemicals and metals of concern as discussed in section 5.1.2. With the exception of acetone, all subsurface soil samples were well below the RFCA action levels for subsurface soils. Low concentrations of volatile organic compounds (VOCs) (i.e., acetone and toluene) have been identified in the Solar Ponds Plume groundwater. The concentrations of VOCs in the plume on the northern side of the Solar Evaporation Ponds do not exceed RFCA Tier II concentrations or are non-detects. Several metals (including selenium) exceed the RFCA groundwater action levels.

The maximum detected concentrations of radionuclides, chemicals, and metal contaminants in the groundwater and subsurface soil/bedrock from contaminant investigations of the Solar Ponds Plume area are shown in Table 3-1. Ref. 2, Section 4, Figures II.4.4-1 through II.4.4-27, and Figures II.4.5-1 through II.4.5-20, provides surficial and subsurface soil contaminant sampling data specific to the Solar Ponds Plume Project area.

Table 3-1 Maximum Detected Contaminants in Surficial and Subsurface Soils, and Groundwater

Compound	Subsurface Soil Concentration	Groundwater Concentration	40 CFR 302.4 RQ
Radionuclides			
Americium-241	0.25 pCi/g	ND	0.01 Ci
Cesium-134	0.02 pCi/g	ND	1 Ci
Plutonium-239/240	0.44 pCi/g	ND	0.01 Ci
Radium-226	0.75 pCi/g	ND	0.1 Ci
Strontium-89,90	0.80 pCi/g	ND	0.1 Ci
Uranium-233/234	1.80 pCi/g	ND	0.1 Ci
Uranium-235	0.10 pCi/g	242.70 pCi/L	0.1 Ci
Uranium-238	1.90 pCi/g	105.20 pCi/L	0.1 Ci
Chemicals, Metals			
Acetone	14.0 µg/kg	ND	2268 kg
bis (2-ethylhexyl) phthalate	3,600.00 µg/kg	ND	45.40 kg
Cadmium	3.40 mg/kg	5 µg/L	4.54 kg
Cyanide	4.26 µg/g	ND	4.54 kg
Mercury	0.21 mg/kg	0.82 µg/L	0.454 kg
Methylene chloride	25.00 µg/kg	ND	454 kg
Nickel	ND	321 µg/L	45.40 kg
Selenium	ND	1510 µg/L	4.54 kg
Silver	ND	5.6 µg/L	454 kg
Thallium	ND	26.1 µg/L	454 kg
Toluene	330.00 µg/kg	ND	454 kg
Zinc	116.40 mg/kg	ND	454 kg

ND = Not Detected

4. SAFETY ANALYSIS

4.1 Hazard Categorization - Radiological

The total quantity of radionuclides that could potentially be exposed and subject to an airborne release during the Solar Ponds Plume Project includes (1) the quantities present in the soil excavated during installation of the collection and treatment systems, OR (2) the quantities absorbed on the reactive media during groundwater treatment. The quantities absorbed during treatment would not be releasable until such time that the media is removed from the treatment system. When the absorptive capacity of the media is exceeded, the material will be removed, stored as necessary, managed, and disposed as low-level or low-level mixed waste.

Using the formula shown below, quantities of radiological contaminants present in the soil excavated and then replaced during the project are less than the DOE-STD-1027-92 Category 3 Nuclear Facility thresholds, and, individually, less than the 40 CFR 302 RQs for the radionuclides. Maximum radionuclide activity concentrations are taken from Table 3-1.

A_T = Total Activity (pCi) = A x ρ x V

A = maximum activity concentration, pCi/g from Table 3-2

ρ = soil density = 1.8 g/cm^3

V = estimated soil volume excavated = 255,000 ft^3

The estimated soil volume was determined based on excavating a trench 10-feet wide, 850 feet long, and 30-feet deep. The total activities of radionuclides that could potentially be exposed and subject to an airborne release during project excavation activities are calculated and presented in Table 4-1.

As can be seen from the calculation results, no individual 40 CFR 302 RQs for Solar Ponds Plume Project radionuclide contaminants will be exceeded. The sum of the ratios exceeds 1.00. However, an acute release of a sum of the ratios RQ quantity of radionuclides that could adversely affect the collocated worker or the public is considered improbable due to the nature of the Solar Pond Plume remediation activities.

Table 4-1 Radiological Contaminants in Soil

(input activity concentration & soil volume [255,000 ft^3] calculates activity)

Radionuclide Contaminant	Maximum Activity of Contaminant found in Soil (pCi/g)	40 CFR 302 RQ (Ci)	Activity (Ci)	Ratio (Activity/RQ)
Americium-241	0.25	0.010	3.25E-01	3.25E+01
Cesium-134	0.02	1.000	2.60E-04	2.60E-04
Plutonium-239/240	0.44	0.010	5.72E-03	5.72E-01
Radium-226	0.75	0.100	9.75E-02	9.75E-01
Strontium-89,90	0.80	0.100	1.04E-02	1.04E-01
Uranium-233/234	1.80	0.100	2.34E-02	2.34E-01
Uranium-235	0.10	0.100	1.30E-03	1.30E-02
Uranium-238	1.90	0.100	2.47E-02	2.47E-01
		Sum of the Ratios		1.59E+00

Activity in Ci (Column 4) = Activity in pCi/g (Column 2) x 1E-12 Ci/pCi x Volume of Soil in ft^3 x 1.8 g/cm^3 x 28316.8 cm^3/ft^3

Uranium-235 and uranium-238 are the groundwater radionuclide contaminants identified by data provided by the project in Ref. 1. The minimum volume of groundwater that would have to be treated to concentrate uranium-235 and uranium-238 on the treatment media exceeding the 40 CFR 302.4 RQ is provided in Table 4-2.

The maximum estimated volume of water that will be collected from the Solar Ponds Plume each year is approximately 3.4 million gallons. Comparing the maximum volume collected to the volume that would exceed the RQs for uranium-235 and uranium-238, it can be reasoned that the radiological contaminant quantities available and subject to an airborne release at any given time during project activities will be far less than the RQ for either contaminant.

Table 4-2 Radiological Contaminants in Groundwater
(input activity concentration; calculation amount of groundwater to exceed 40 CFR 302 RQs)

Radiological Contaminant	Maximum Activity of Contaminant found in Groundwater (pCi/L)	40 CFR 302 RQ (Ci)	Volume of Water (liters) to Exceed 40 CFR 302 RQ	Volume of Water (gallons) to Exceed 40 CFR 302 RQ
Uranium-235	242.70	0.100	4.12E+08	1.09E+08
Uranium-238	105.20	0.100	9.51E+08	2.51E+08

Volume of Groundwater to Exceed 40 CFR 302 RQ in Liters (Column 3) = [RQ in Ci x 1E12 pCi/Ci] / Activity in pCi/L (Column 2)

4.2 Hazard Classification – Chemicals and Metals

The hazard classification for chemicals is assigned based on a comparison of the chemical inventories to the hazardous substance RQs in 40 CFR 302 (Ref. 8). Table 4-3 presents the maximum concentrations of the Solar Ponds Plume chemicals and metals and the quantity of contaminant estimated in excavated soils. Based on the data in Table 3-1, cadmium is the chemical with the highest subsurface soil concentration and the lowest RQ), or the bounding chemical. Additionally, 40 CFR 302 RQs for bis (2-ethylhexyl) phthalate, mercury, and zinc will be exceeded during Solar Pond Plume Project activities. However, an acute release of a greater-than-RQ quantity of hazardous materials that could adversely affect the collocated worker or the public is considered improbable due to the nature of the Solar Pond Plume remediation activities.

Table 4-3 Hazardous Materials in Soil
(input concentration & volume of soil disturbed [255,000ft³]; calculates quantity of contaminant)

Contaminant	Maximum Concentration of Contaminant found in Soil (mg/kg)	40 CFR 302 RQ (kg)	Quantity of Contaminant (kg)
Acetone	0.014	2,268.00	0.18
BIS (2-ethylhexyl) phthalate	3.600	45.40	46.79
Cadmium	3.400	4.54	44.19
Cyanide	0.004	4.54	0.06
Methylene chloride	0.025	454.00	0.32
Mercury	0.21	0.45	2.73
Toluene	0.33	454.00	4.29
Zinc	116.40	454.00	1512.90

Quantity of Contaminant in kg (Column 4) = Maximum Concentration in mg/kg (Column 2) x [Volume of Soil in ft³ x 1.8 g/cm³ x 28316.8 cm³/ft³ x 0.001 kg/g] x 1E-6 kg/mg

Table 4-4 lists the maximum concentrations of the Solar Ponds Plume chemicals and metals present in the groundwater and the quantity of water that would equal or exceed the 40 CFR 302 RQ. The maximum estimated volume of water that will be collected and treated from the Solar Ponds Plume each year is approximately 3.4 million gallons, over a 30-year period. Comparing the maximum groundwater volume collected annually to the groundwater volume

that would result in an exceedance of the RQs for chemicals and metals in Table 4-4, only the contaminant selenium has the potential to exceed the 40 CFR 302 RQ in a given year. An acute release of selenium exceeding its 40 CFR 302 RQ that could adversely affect a collocated worker or the public is considered improbable due to the nature of the Solar Pond Plume remediation activities.

Table 4-4 Hazardous Materials in Groundwater

(input concentration & volume of water to exceed 40 CFR 302 RQs)

Contaminant	Maximum Concentration of Contaminant (ug/L or ppb) in Water	40 CFR 302 RQ (kg)	Volume of Water (liters) to Exceed 40 CFR 302 RQ	Volume of Water (gallons) to Exceed 40 CFR 302 RQ
Cadmium	5.00	4.54	9.08E+08	2.40E+08
Mercury	0.82	0.45	5.49E+08	1.45E+08
Nickel	321.00	45.40	1.41E+08	3.74E+07
Selenium	1,510.00	4.54	3.01E+06	7.94E+05
Silver	5.60	454.00	8.11E+10	2.14E+10
Thallium	26.10	454.00	1.74E+10	4.60E+09

Volume of Groundwater to Exceed 40 CFR 302 RQ in Liters (Column 4) = [RQ in kg (Column 3) x 1,000 g/kg] / [Concentration in µg/L (Column 2) x 1E-06 g/µg]

Based on the concentrations of chemicals and metals in the surficial and subsurface soil, and groundwater, and the amount of soil and groundwater that will be handled during Solar Ponds Plume Project activities, 40 CFR 302 RQs for cadmium, bis (2-ethylhexyl) phthalate, mercury, zinc, and selenium will be exceeded.

4.3 Hazard Categorization

Based on the guidance in DOE-STD-5502-94 and project characterization data, the Solar Ponds Plume Project is classified as *radiological* requiring compliance with applicable OSHA Standards, preparation of a site-specific Health and Safety Plan, and preparation of an auditable safety analysis. This categorization was determined as follows:

- Potentially releasable radioactive material does not meet or exceed DOE-STD-1027-92, Attachment 1, Nuclear Facility Hazard Category 3 thresholds,
- Potentially releasable radioactive material meets or exceeds 40 CFR 302, Appendix B RQ levels, when summing the ratios (see Table 4-1), and
- Potentially releasable hazardous chemicals meet or exceed 40 CFR 302, Table 302.4 RQ levels (see Tables 4.3 and 4.4)

4.4 Accident Analysis

Based on the *radiological* classification of the Solar Ponds Plume Project, formal accident analysis is not required.

5. HAZARD CONTROLS

This safety analysis is predicated on conformance with the site-specific HASP and compliance with applicable OSHA standards. Unforeseen and/or uncharacterized hazards will be managed in accordance with RMRS Operations Directive OPS-DIR-001, *Safety and Environmental Stewardship Directive* (Ref.10) that states:

> "It is the intent of RMRS to adequately address unexpected hazards or conditions encountered during environmental restoration, waste management, and decontamination and decommissioning activities. In the event that unanticipated hazards or conditions are encountered, the project activities will pause to assess the potential hazard or condition. The potential hazard or condition will be evaluated to determine the severity or significance of the hazard or condition and whether the existing project controls are sufficient to address the hazard or conditions. Based on this initial evaluation, a determination will be made whether to proceed with controls currently in place, segregate the condition or hazard from the project activity, if this can be done safely; or curtail operations to address the unexpected hazard or condition. Concurrence to proceed down the selected path must be obtained from the respective RMRS Director or their designee."

Additionally, RMRS Operations Directive OPS-DIR-002, *Authorization Basis,* (Ref. 11), requires a revised or new authorization basis if project operational controls are not sufficient to adequately address unanticipated hazards or conditions that are encountered. The project or technical manager is responsible for recognizing these unanalyzed situations and requesting the necessary evaluation and revision to the applicable authorization basis in order to proceed with the work in a safe and compliant manner.

6. REFERENCES

1 *Draft Solar Ponds Plume Decision Document,* **RF/RMRS-98-286.UN,** Rocky Mountain Remediation Services L.L.C., November 20, 1998

2 *OU4 Solar Evaporation Ponds Interim Measure/Interim Remedial Action Environmental Assessment Decision Document,* Part II, Volume I, Revision: Proposed, U. S. Department of Energy, Rocky Flats Environmental Technology Site, Golden, Colorado, February 1995.

3 *Hazardous Waste Operations and Emergency Response,* **Code of Federal Regulations, 29 CFR 1926.65,** Department of Labor, Occupational Safety and Health Administration, Washington D. C.

4 *Hazard Baseline Documentation,* **DOE-EM-STD-5502-94,** U. S. Department of Energy, Washington D. C., August 1994.

5 *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports,* **DOE-STD-1027-92,** U. S. Department of Energy, Washington D. C., December 1992.

6 *Process Safety Management,* **Code of Federal Regulations, 29 CFR 1910.119,** Department of Labor, Occupational Safety and Health Administration, Washington D. C.

7 *Risk Management Programs (RMP) for Chemical Accidental Release Prevention*, **Code of Federal Regulations, 40 CFR 68**, Office of the Federal Register, Washington D. C.

8 *Designation, Reportable Quantities, and Notification*, **Code of Federal Regulations, 40 CFR 302**, Office of the Federal Register, Washington D. C.

9 *Emergency Planning and Notification*, **Code of Federal Regulations, 40 CFR 355**, Office of the Federal Register, Washington D. C.

10 *Safety and Environmental Stewardship Directive*, Operations Directive, **OPS-DIR-001**, Revision 2, Rocky Mountain Remediation Services, LLC, August 15, 1997.

11 *Authorization Basis*, Operations Directive, **OPS-DIR-002**, Revision 3, Rocky Mountain Remediation Services, LLC, November 1, 1998.